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Anomaly Correlation Coefficients For The Global Model

By

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1. Introduction

The anomaly correlation coefficient relates spatial patterns in the forecast and analysis fields and also gives an indication of the usefulness or skill of a forecast. Anomaly correlation coefficients for forecast fields from the Global Model have been produced for 500mb geopotential height and pressure at mean sea level. This required climate fields which were made from eight years of the Coarse Mesh Model fields. In this note the production of the climate fields and the implementation of the anomaly correlation coefficient (ACC) calculations in the New Verification System are described. Results are given for June 1994.

2. Anomaly Correlation

The anomaly correlation coefficient measures the correlation between two anomalies, where the two anomalies are made from the same reference field. In this case the analysis-climate anomaly and the forecast-climate anomaly are used. This gives a measure of the spatial phase difference between these two anomalies (Stanski et al, 1989). The analysis-climate anomaly is formed by subtracting the climate field from the analysis field at every grid point, and similarly the forecast-climate anomaly is the difference field between the forecast and climate. The correlation coefficient between two fields X and Y is given by r, where

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}}$$

x is the deviation from the mean of X: $x = X - \overline{X}$

y is the deviation from the mean of Y: $y = Y - \overline{Y}$

and the mean is over the same set of points for each field (Hannagan, 1990). Applying this to the two anomalies for a grid point field gives the anomaly correlation coefficient (ACC), (Nieminen, 1983).

$$ACC = \frac{\sum_i w_i \left[F_i - C_i - \overline{(F-C)}\right] \times \left[A_i - C_i - \overline{(A-C)}\right]}{\sqrt{\sum_i w_i \left[F_i - C_i - \overline{(F-C)}\right]^2 \times \sum_i w_i \left[A_i - C_i - \overline{(A-C)}\right]^2}}$$

where F_i, A_i, C_i, are respectively the forecast, analysis and climate field values at the i-th grid-point. The sum is taken over all the grid points in the area, w_i is the weighting of the field at each grid point, and an over bar ($\overline{.....}$) denotes an area mean.

Subtracting the area mean anomaly from the set removes any systematic differences from the sum, so the ACC is not affected by the mean values of the anomalies. Similarly the ACC is not affected by the mean error of the forecast. For example, if 1mb is subtracted from every point in the forecast field for pressure, before calculating the ACC, the result will be the same as the ACC for the original forecast field.

A simple example of the ACC may be considered when the anomalies are sine waves along the x-axis, with the same wavelength but with a spatial phase difference ϕ,

$$A - C = a \sin kx \qquad F - C = b \sin(kx + \phi)$$

Integration of the product of these anomalies over x from 0 to 2π/k then gives ACC = $\cos\phi$. However for more complicated anomaly patterns the relationship between ACC and phase difference is not so straightforward. For a general 1D situation where the anomalies vary in the x-direction only the anomalies contain several sine waves, each contributing to the ACC. The sine waves are weighted according to the fourier components of the anomaly. The ACC is determined by the combined effect of the phase errors between the sine waves, weighted according to the amplitude of each component.

For a global field, like PMSL or 500mb height, there is variation in both latitude and longitude. The global field can conveniently be represented as a sum of a series of spherical harmonic waves. The coefficient (a + ib) of each spherical harmonic give its phase and amplitude. The anomalies will then be a sum of spherical harmonics, and again the ACC will be affected by the (spatial) phase errors of these waves, weighted according to their amplitudes. In an anomaly pattern some waves are dominant. The dominant waves in the pattern, i.e. the large amplitude waves, contribute most to the ACC. These waves generally have long wavelength, for example the 500mb height pattern typically shows a large wave with 5 or 6 cycles round a latitude band. If the anomaly patterns have similar general features then the ACC gives an indication of the spatial phase differences of the dominant waves between the two anomaly patterns.

The values of the ACC lie in the range +1 to -1. An ACC value of +1 corresponds to perfect correlation and zero phase difference between the two anomalies, while an ACC of -1 indicates that the two anomalies are in anti phase. An ACC of zero may indicate that there is a phase difference of +/-90° or no correlation at all, or a combination of large phase errors and lack of similarity between the 'shape' of the anomaly patterns.

Hollingsworth et al (1980) looked at weather patterns for February 1976 in the Northern hemisphere. Synoptic evaluations of when the forecasts stopped giving useful guidance were made, and were found to correspond to an ACC score of about 0.6. *Therefore an ACC value of 0.6 is considered to be the lower limit for a useful forecast.* (It is assumed that this is also true for the model used by the Met.Office.)

Murphy and Epstein (1988) define the climatological skill score (SS) as

$$SS(F,C,A) = 1 - \frac{MSE(F,A)}{MSE(C,A)}$$

where MSE is the mean square error. They show that in general the skill score is equal to the ACC squared minus several other terms relating to biases in the forecast. This means that generally the square of the ACC may be seen as a measure of the *potential* skill of the forecast, if the biases were not there. Another expression is gained for SS and ACC for the following conditions, a) the area mean of the analysis-climate anomaly is close to zero, b) the mean error in the forecast is negligible, c) a realistic atmospheric variability is maintained in the forecast

fields. The relation is then

$$SS(F,C,A) = (2 \times ACC) - 1.$$

Under these conditions if the ACC=0.6 then the skill score SS=0.2 or 20%, and also if the ACC is less than 0.5 then the SS is negative. This is in line with taking an ACC of 0.6 as the lower limit for useful forecasts. The trend of ACC values over several years can be used to evaluate improvements in the reliability of model forecasts (Branstator, 1986).

3. Climate Fields

Global climate fields for each month of the year have been generated for PMSL and 500mb geopotential height. This was done by forming averages from the monthly analysis fields from the 15-level Coarse Mesh Model, over the period from May 1983 through to May 1991. For use with the Global version of the Unified Model (UM), the climate fields were interpolated onto a 0.833° x 1.25° grid. This section describes how the climate fields were produced.

3.1 The archived data

Since May 1983 the update global analysis fields from the midnight and midday runs have been extracted and a monthly mean of each field has been stored on tape to give a permanent archive. The archived fields were stored in PP format datasets, by using the Met Office post-processing (PP) package. From May 83 to October 86 inclusive the fields were stored in a spectral form, where spherical harmonics had been fitted to the global field , with a T40 truncation giving a maximum wave number of 40 round a latitude circle and 40 round a longitude circle. This gives the same resolution in latitude and longitude and gives an equivalent resolution to a grid point spacing of approximately 4.5 degrees. From November 86 to May 91 inclusive the fields were stored in a packed grid point form with 121 points N-S and 192 points E-W. The archived fields were packed using Met.08 packing routines.

3.2 Accumulation of data

The archived grid point fields were unpacked and then interpolated to spectral fields with a truncation of T40. These spectral coefficients were then added to those from the spectral archive, and meaned for each month over 8 or 9 years. The monthly mean spectral fields were then interpolated to the Unified Model grid (217x288 points) and stored in a database. The processing was done using the PP package, except for the unpacking of the grid point fields which uses the Met.08 routine 'XPAND'.

The archived grid point fields were interpolated by conversion to spectral fields because this type of interpolation preserves the large scale features in the global field, as well as smoothing the field. The archived grid point fields (121x192 lat-long) could have been interpolated with a truncation of T95, but this would not have been consistent for combination with the archived T40 spectral fields.

4. Implementation in the New Verification System

Daily values of the ACC were required and so the monthly climate fields were combined to give a different climate field for each day. The New Verification System is designed to store all the data summations that are needed for computing any first or second order verification statistics (Bromley, 1983). The stored quantities were used to calculate the ACC, and also to give mean and rms errors. The ACC results were tested by comparison with those from another program. The new system is capable of calculating statistics, ACC included, for a variety of areas. All calculations of the ACC are for the Global Model. The ACC is unlikely to be implemented for the LAM and Mesoscale models due to the size of their areas and the dominant waves having long wavelengths.

4.1 Daily Climate Fields

The monthly mean climate fields can be considered to be valid on the middle day (15th or 16th) of each month. For daily ACCs a daily climate field is required. This will prevent a large change in the climate field at the change of month. To make a climate field for a given date a linear interpolation is done on the field for that month and either the preceding or following month. This effectively takes the fields for 14 or 15 days on either side of the given date. For example, the field for the 10th April is determined from the following combination:

10 April = 25/30 April + 5/30 March.

4.2 Calculation of anomaly correlation coefficients

The new verification system is set up so that after each forecast run it extracts analysis, persistence, forecast and climatology fields and uses these to form certain statistical quantities. Those relevant here are mean fields and mean square errors between fields, as follows:-

$$\frac{\sum_i w_i A_i}{\sum_i w_i} \qquad \frac{\sum_i w_i F_i}{\sum_i w_i} \qquad \frac{\sum_i w_i C_i}{\sum_i w_i}$$

called *AMN*, *FMN*, *CMN* respectively, and

$$\frac{\sum_i w_i (F_i - A_i)^2}{\sum_i w_i} \qquad \frac{\sum_i w_i (F_i - C_i)^2}{\sum_i w_i} \qquad \frac{\sum_i w_i (A_i - C_i)^2}{\sum_i w_i}$$

called *FAMN*, *FCMN*, *ACMN* respectively.

where A_i, F_i, C_i, are the analysis, forecast and climate fields, and w_i the weighting at each i grid point. Working from the original definition of ACC ,(section 2), the ACC may be expressed in terms of the above quantities.

$$ACC = \frac{\frac{1}{2}(FCMN + ACMN - AFMN) - [(AMN - CMN) \times (FMN - CMN)]}{\sqrt{[FCMN - (FMN - CMN)^2] \times [ACMN - (AMN - CMN)^2]}}$$

This is the calculation of ACC which has been implemented.

4.3 Testing

The new system's results for the ACC were compared with those from another program used by D. Richardson(FR). This program calculated the ACC directly by forming the sums in the original expression (section 2). The forecast and analysis fields were taken from the WGDOS archive and a daily climate field was used. The results from the two programs were the same to 3 significant figures. The ACCs for the global field (90N-90S) on the UM grid were the same to within 0.1%, whilst those for the band 90N-20N on the UM grid were the same to within 0.2%.

The climate fields were checked by producing charts for each month of the year. The daily climate fields were checked by hand-calculating certain grid point values from theappropriate monthly fields. The general reasonableness of the ACC results was considered, and comparisons were made with results from ECMWF.

5. Results

5.1 CBS results for June 1994

The results are from the Global Model and have been interpolated onto the CBS 2.5° x 2.5° grid. The globe has been split into three areas, Northern 90N-20N, Tropics 20N-20S, and Southern 20S-90S. Monthly mean anomaly correlation coefficients (ACC) were calculated for June for 500mb geopotential height and pressure at mean sea level (PMSL) , combining the midnight (00z) and midday (12z) forecast runs, and the results are shown in Tables 1a and 1b. (The monthly mean ACCs for the 00z and 12z runs were calculated separately and found to be very similar, typically differing by less than 0.01 but with a maximum variation of 0.06 for T+144 in the Tropics.)

The monthly mean ACC values for 500mb height are always better than the corresponding values for PMSL. For the 1 to 6 day forecast ranges the Northern area has fairly good values for ACC, with the monthly ACC above 0.6 for the 6 day forecast for 500mb height and for the 5 day forecast for PMSL. The Southern area does slightly less well, with the monthly ACC remaining above 0.6 for both the 5 day forecasts. The Tropics have fairly poor values for ACC, and the monthly ACC only remains above 0.6 for the 2 or 3 day forecasts.

The poorer values of the ACC in the Tropics are probably because, in the Tropics, there is not much spatial or temporal variation about the mean in the PMSL or 500mb height fields. So there is not a strong spatial pattern in these fields around the tropical band. It seems that the weakly varying pattern in these fields is not forecast so well, although the forecasts have small mean and root mean square errors. The Northern and Southern areas have large amplitude spatial patterns and these have been forecast fairly well, even though the mean and rms errors are greater.

Daily values of the ACC for June were calculated and used in a set of time series showing the ACC for 1 to 6 day forecasts for each day of the month. The daily time series for 500mb height and PMSL for the Northern area shown in Figures 1 and 2. These graphs only use the 00z runs, but graphs of the 12z runs are similar. For the Northern area the daily ACC values for 500mb height and PMSL follow similar trends. For the whole month the 1, 2, and 3 day forecasts have good ACC values and have little variation from their monthly mean ACC

values. The ACC for the 4 day forecast always stays above 0.6, although it varies more. The ACC values for the 5 and 6 day forecasts vary considerably from the monthly mean, and have several days when the ACC is below 0.6. The 5 and 6 day ACCs seem to have 'good' periods, 15-25 June, and 'bad' periods, 10-13 June.

The Southern area is similar to the Northern area for ACC trends. The ACCs for 1, 2 and 3 day forecasts are generally good and show little variation, and the 4 day forecasts have ACC values above 0.6. The 5 and 6 day forecasts vary more, and again have 'good' periods, 10-20 June, and 'bad' periods.

In the Tropics the ACC values are worse, and ACC values for 500mb height and PMSL follow similar trends to each other. The ACCs for all forecasts show a lot of variation, and only the 1 day forecast has an ACC that remains above 0.6 for the whole month. There seems to have been a better period at the beginning of the month, but after 11 June the ACC values generally worsen considerably and stay low for the rest of the month, although the ACCs for 500mb height make a temporary recovery on 22 June.

5.2 Unified Model results

The results are from the Global Model and so are on the 0.833° x 1.25° grid. Results are given for the areas 90N-30N, 30N-30S, 30S-90S, Limited Area Model (LAM) area, and 'UK and Iceland' area, (Tables 2a and 2b). Monthly mean ACCs and daily time series were produced for these areas. (For historical reasons the UM results are routinely produced for the areas 90N-30N, 30N-30S, 30S-90S.)

The monthly mean ACCs for 90N-30N and 30S-90S are either the same or very slightly better than those for the CBS areas 90N-20N and 20S-90S, respectively. The daily time series for these UM and CBS areas are also very similar. Conversely the monthly mean ACC for 30N-30S is considerably greater than that for the CBS area 20N-20S. This is probably because the larger amplitude patterns in the 20° - 30° bands make a large contribution to the ACC for 30N-30S compared with the weaker patterns in the 20N-20S band which do not seem to be forecast as well.

The monthly mean ACCs for the LAM area are better than the ACCs for the whole Northern area 90N-30N. The monthly mean ACC is above 0.6 for the 6 day forecast for 500mb height, and for the 5 day forecast for PMSL.

The monthly mean ACCs for the 'UK & Iceland' area also have high values. However the 'UK & Iceland' area is *too small* for the ACC to be a useful measure of the forecasts as only part of the long wave features cover this area. The area also only contains 869 model points. The daily ACCs for the 4, 5 and 6 day forecasts vary dramatically, and on several runs the ACC for the 6 day forecast is better than the ACC for the 5, 4 and 3 day forecasts.

5.3 Comparison of results on UM and CBS grids

The ACCs for PMSL on the UM grid and the CBS grid were compared for the areas 90N-20N (Northern), 20N-20S (Tropics), and 20S-90S (Southern). The purpose is to see if interpolation to the lower resolution grid affects the ACC. The UM grid is 0.833° x 1.25° , which gives the smallest resolvable north-south wavelength as 120 miles. The CBS grid is

2.5° x 2.5° , which gives the smallest north-south wavelength as 360 miles. The comparison was only done for 6 runs of the Global Model, which were on 7-12 June for 00z runs. This period is not long enough to show if interpolation changes the *average* ACC results. At least a month would be needed. However, it does show that, on a daily basis, interpolation changes the ACC values slightly, and suggests there could be minor differences in the average results. For the 6 days of data some trends were noted. For the Northern area the average ACCs over the 6 days were slightly better on the UM grid, in the Tropics the average ACCs on the UM and CBS grids were the same, and in the Southern area the average ACCs were slightly better on the CBS grid. On a daily basis the ACCs for each forecast range generally followed the same trends on changing grid as the 6-day averages.

5.4 Anomaly correlation coefficient using persistence (tendency correlation coefficient)

An anomaly correlation coefficient has also been calculated with persistence as the reference field, instead of the climate field. The persistence field is the analysis field from the day the forecast was made. The resulting coefficient has also been known as the tendency correlation coefficient. This coefficient will be indicated by TCC: ACCwill be reserved for the coefficient computed with respect to the climate fields.

A qualitative idea of the likely values of the ACC and TCC can be gained by considering the model vector space in which the fields are specified (Bromley, 1983). The climate field will be at the centre of a distribution of individual analysis fields. On average, any one analysis field will lie as far from the climate field as another analysis. A forecast from a given starting analysis will have another, later analysis as its validating field. The original analysis is then the persistence field. The persistence field and the validating analysis may be expected to lie at the same distance from the climate field. It is therefore possible to construct a sphere in the model vector space, with the climate field at its centre and the persistence and validating analysis on the circumference. If the forecast lies on the surface of the sphere, the arc formed by the difference between the forecast and the verifying analysis will subtend an angle, P, at the centre of the sphere (the climate field) and another angle, Q, on its circumference, including the persistence analysis. Since the correlation coefficients are given by the cosines of these angles,

$$TCC = \cos Q \qquad \text{and} \qquad ACC = \cos P$$

By standard geometry, Q is half P, so the TCC will be bigger than the ACC. However, the precise relationship between Q and P does not hold good because in practice there are too many sources of error. In particular, the amplitudes of the differences between the model fields and climate, especially between the forecast fields and the climate, are not sufficiently similar to allow the relationship to hold.

Monthly mean values of the coefficients were calculated on the CBS grid, and are shown in Table 3. For 1 and 2 day forecasts the monthly mean ACCs are greater than the monthly mean TCC. But by the T+60 forecast the monthly mean TCCs are higher than the ACCs, and remain higher through to the 6 day forecast. In the Northern and Southern areas, the ACC using persistence does not start with very high values but falls off gradually with forecast day so that by day 6 it is considerably greater than the ACC using climatology. This is also true in the Tropics except that the ACC using persistence increases up to T+60 before gradually decreasing.

6. Conclusions

The ACC values have been produced and some conclusions are made from the results for June. The monthly mean ACCs have good values for both the Northern and Southern areas. In these areas the 1 to 4 day forecasts can be relied upon to provide some useful guidance, as the daily ACCs remain above 0.6 for the whole month. The 1, 2, and 3 day forecasts have consistent ACC values in line with their monthly means. The 5 and 6 day forecasts can be useful, more so for 500mb height, but can also be misleading as they have several days below 0.6 and 0.5. It is not known if it can be decided in advance when the 5 and 6 day forecasts are likely to be poor or reasonable.

In the Tropics the monthly mean ACC values are fairly poor, with only the 3 day forecasts (500mb height), or the 2 day forecasts (PMSL), having a mean ACC above 0.6. The 1 day forecast provides useful guidance, although the daily ACC drops below 0.6 on one occasion. The 2 day forecast is usually useful and the 3 day forecast has ACCs above 0.6 for at least half the occasions. Beyond 3 days not much faith can be put in the forecast of patterns for these fields. The weakly varying patterns in these fields are not forecast very well, although the mean and rms errors are small. It is intended to verify 850mb height and temperature fields which are though to be more important in the Tropics.

7. Acknowledgements

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Table 1a. CBS results for June 1994. (00z and 12z runs combined). 500mb geopotential height (in metres)

Area	Forecast range (hrs)	Forecast mean	Analysis mean	Mean error	RMS error	ACC
90N-20N	24	5711	5715	-4	13	0.99
	48	5708		-7	23	0.96
	72	5707		-8	35	0.90
	96	5706		-9	48	0.81
	120	5703		-12	59	0.72
	144	5701		-13	70	0.61
20N-20S	24	5860	5862	-3	7	0.79
	48	5859		-3	8	0.75
	72	5859		-3	10	0.64
	96	5860		-3	10	0.59
	120	5860		-2	12	0.51
	144	5861		-1	12	0.47
20S-90S	24	5486	5471	-3	24	0.98
	48	5465		-6	43	0.93
	72	5461		-10	62	0.86
	96	5459		-12	78	0.77
	120	5459		-12	95	0.66
	144	5459		-12	110	0.54

Table 1b. CBS results for June 1994. (00z and 12z runs combined). PMSL (in mb)

Area	Forecast range (hrs)	Forecast mean	Analysis mean	Mean error	RMS error	ACC
90N-20N	24	1011.6	1011.7	-0.2	2	0.96
	48	1011.5		-0.2	3	0.91
	72	1011.6		-0.1	4	0.84
	96	1011.7		-0.1	5	0.74
	120	1011.6		-0.1	5	0.63
	144	1011.6		-0.2	6	0.54
20N-20S	24	1011.6	1011.7	-0.1	1	0.74
	48	1011.7		0.0	1	0.66
	72	1011.8		0.2	2	0.57
	96	1011.9		0.3	2	0.52
	120	1012.0		0.4	2	0.45
	144	1012.1		0.4	2	0.42
20S-90S	24	1008.2	1008.0	0.2	3	0.96
	48	1008.2		0.2	5	0.90
	72	1008.0		0.0	6	0.82
	96	1007.9		-0.1	8	0.72
	120	1007.9		-0.1	9	0.62
	144	1007.8		-0.2	10	0.52

Table 2a. UM results for June 1994. (00z and 12z runs combined). Anomaly correlation coefficients for 500mb geopotential height.

Area	Forecast Range (hrs)					
	24	48	72	96	120	144
UK & Iceland	.99	.97	.91	.85	.80	.74
LAM	.99	.96	.91	.82	.73	.63
90N-30N	.99	.96	.91	.82	.72	.62
30N-30S	.93	.87	.78	.70	.61	.51
30S-90S	.98	.93	.86	.77.	.66	.54

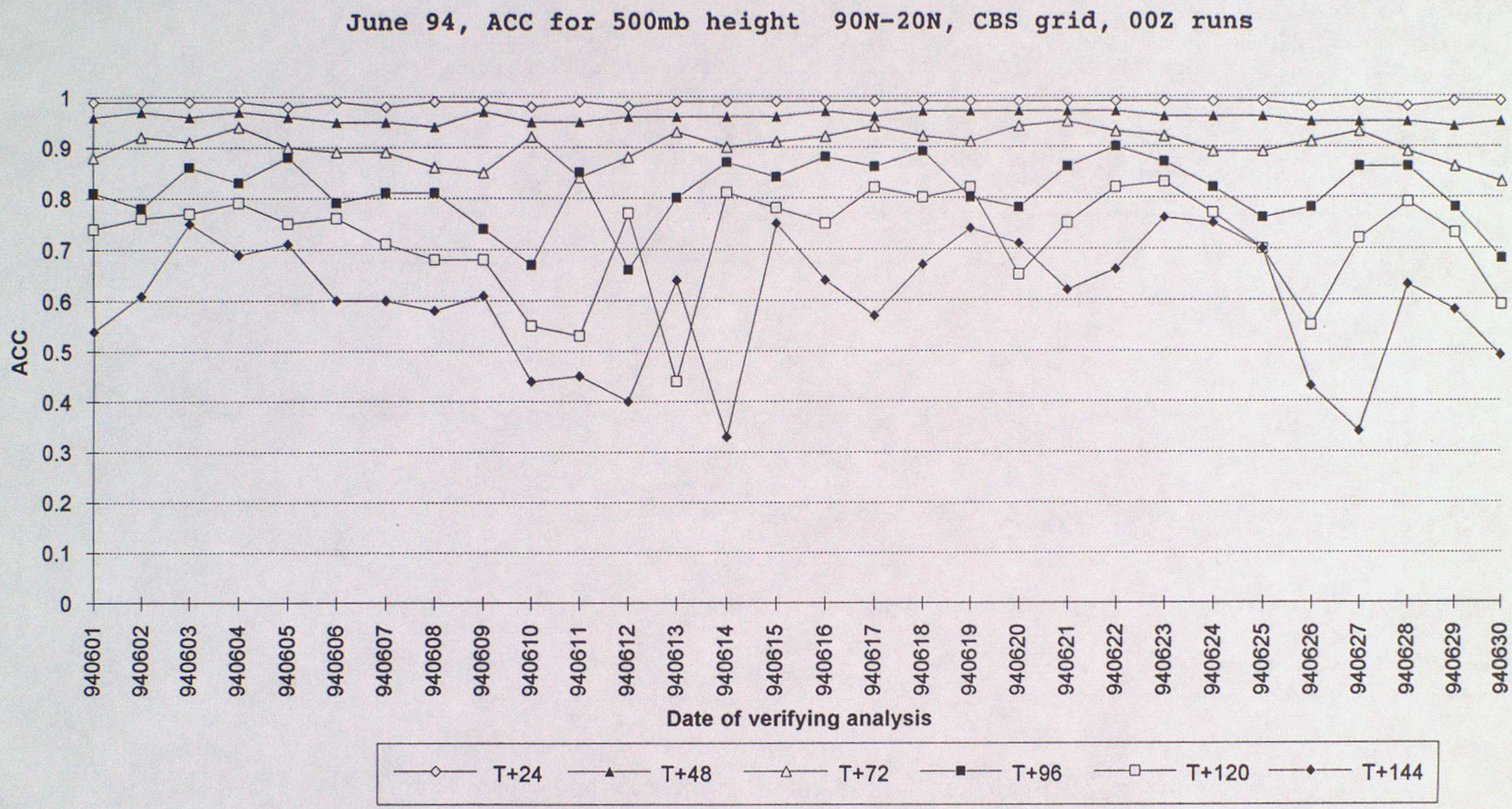
Table 2b. UM results for June 1994. (00z and 12z runs combined). Anomaly correlation coefficients for PMSL.

Area	Forecast Range (hrs)					
	24	48	72	96	120	144
UK & Iceland	.98	.92	.83	.74	.66	.59
LAM	.97	.92	.85	.74	.65	.57
90N-30N	.96	.91	.85	.75	.64	.55
30N-30S	.85	.78	.70	.63	.55	.48
30S-90S	.96	.90	.82	.73	.63	.52

Table 3. Anomaly correlation coefficients using climatology (ACC C) and persistence (ACC P) for 500mb geopotential height and PMSL, on the CBS grid.

Area	Forecast Range (hrs)	500mb height		PMSL	
		ACC C	ACC P	ACC C	ACC P
90N-20N	24	.99	.97	.96	.93
	48	.96	.95	.91	.91
	60	.93	.93	.88	.90
	72	.90	.91	.84	.87
	96	.82	.86	.74	.81
	120	.72	.81	.63	.76
	144	.61	.75	.54	.70
20N-20S	24	.79	.68	.74	.57
	48	.75	.77	.66	.64
	60	.70	.78	.62	.71
	72	.64	.76	.57	.63
	96	.59	.76	.52	.63
	120	.51	.73	.45	.59
	144	.47	.73	.42	.59
20S-90S	24	.98	.95	.96	.93
	48	.93	.92	.90	.90
	60	.89	.90	.87	.88
	72	.86	.88	.82	.85
	96	.77	.84	.72	.81
	120	.66	.79	.62	.75
	144	.54	.73	.52	.68

Figure 1.


June 94, ACC for 500mb height 90N-20N, CBS grid, 00Z runs
ACC
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
940601
940602
940603
940604
940605
940606
940607
940608
940609
940610
940611
940612
940613
940614
940615
940616
940617
940618
940619
940620
940621
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940623
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940626
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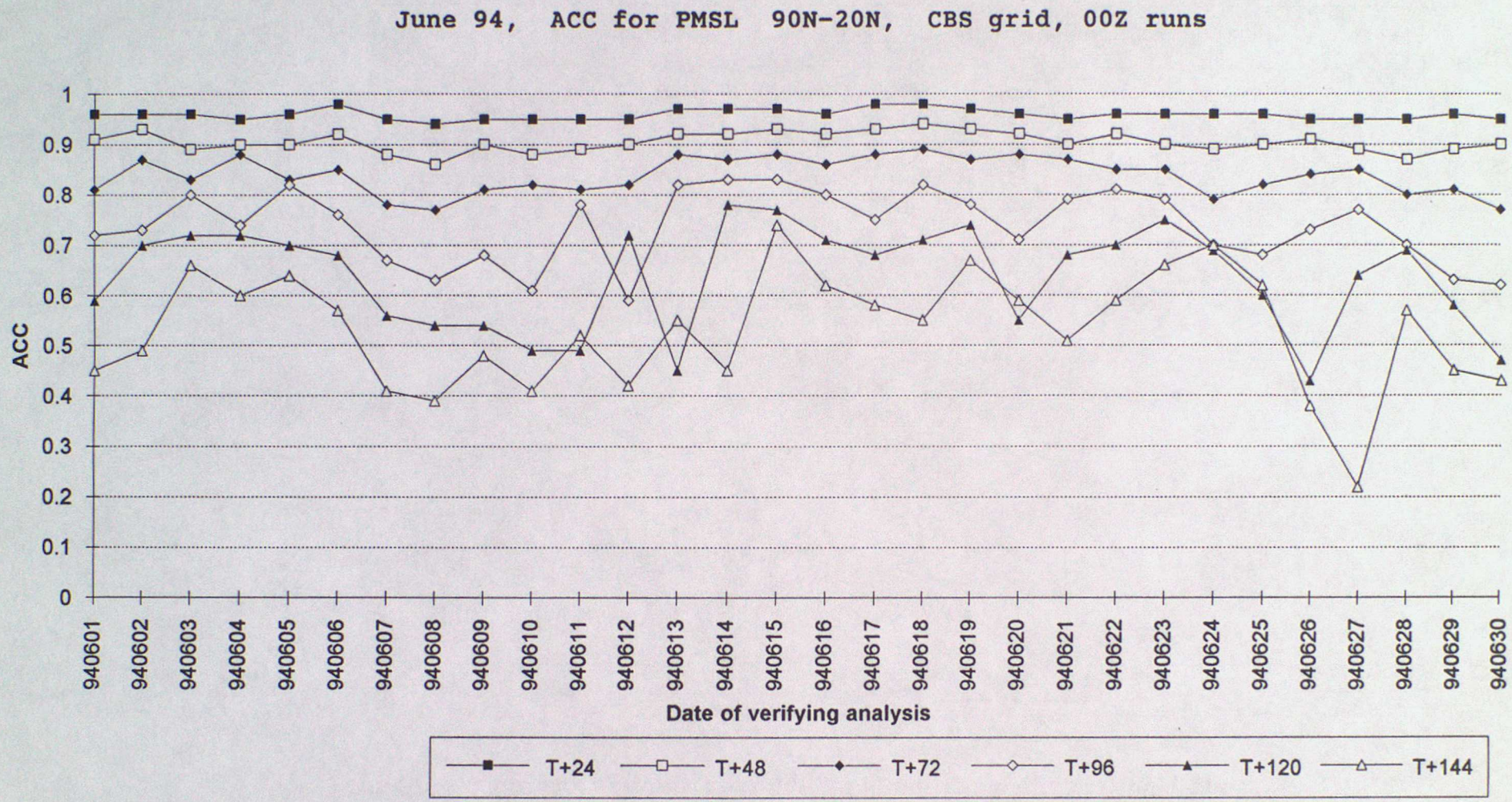
T+72
T+96
T+120
T+144

Figure 2.


June 94, ACC for PMSL 90N-20N, CBS grid, 00Z runs
ACC
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
940601
940602
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Date of verifying analysis
T+24
T+48
T+72
T+96
T+120
T+144

APPENDIX 1

Datasets and Programs used

Datasets

All datasets have PP headers.

Archive of global monthly fields.
These fields are stored as spectral coefficients (T40) from May 83 to Oct 86:-
MCF6.JPNARCH.MAY1983, MCF6.JPNARCH.JUN1983, etc.
These fields are stored as grid point fields (121x192) from Nov 86 to May 91:-
MCF6.JPGARCH.NOV1986,...., MCFG.JPGARCH.MAY1991.

Global monthly mean climate fields formed over 8 or 9 years.
These fields are stored as spectral coefficients (T40) :-
CFVER.CDSPCT40.JAN,....., CFVER.CDSPCT40.DEC.
These fields are also stored at Unified Model resolution:-
COP.VERISYS.CDB.

Programs

Programs used to restore datasets:-
CFVER.CD.CNTL(RESTOREC)

Programs used to form monthly mean spectral climate fields over 8 or 9 years :-
CFVER.CD.CNTL(PPPSPT), and CFVER.CD.CNTL(PPSPC6).

Programs used to interpolate the above spectral climate fields to the Unified Model grid:-
CFVER.CD.CNTL(PPPSPT), and CFVER.CD.CNTL(PPSPC2)

Programs used to calculate ACC in the New Verification System:-
CFVER.VFGENC2.FORT(ANOMCC)

Programs used to calculate ACC by direct method:-
CFVER.CD.CNTL(SKILLJCL), CFVER.CD.FORT(ANOMCR),
CFVER.CD.FORT(WGDOS)

CENTRAL FORECASTING TECHNICAL NOTE

NUMBER	TITLE	AUTHOR	DATE
2	A trial of a scheme to correct the analysed position of tropical cyclones in the operational coarse mesh model.	M. Carter	1988
3	The impact of data on fine mesh forecasts for the storm of January 25 1990.	J. T. Heming	1990
4	Trial of the impact of bogus data in the fine mesh model.	J. T. Heming	1990
5	A guide to numerical weather prediction models and their output.	C. D. Hall	1991
6	Results of the trial of the scheme to reposition features in a model analysis by use of bogus data.	J. T. Heming	1992
7	Operational forecasts of tropical cyclone formation in the western north pacific in 1991.	C. D. Hall	1992
8	Aviation climatology derived from the opeational model. May 1983 - May 1991	P. M. Grimes	1992
9	Effectivness of grib packing for wafs	H. H. Ross P. J. Smith S. D. Turner	1993
10	Investigation into the impact of North Atlantic tempships on the forecasts of U.K. Meteorological office's global & Limited area models	J. T. Heming A. M. Radford	1993
11	User documentation for the Frontier program.	P. Sinclair	1992
12	A trial of the impact of intervention in the Global Model.	J. T. Heming	1993
13	On the use of gridded binary code in producing aviation forecast bulletins	P. J. Smith S. D. Turner	1987 1993
14	The use of gridded binary code in producing products from Bracknell for international exchange in FM92-IX GRIB	P. J. Smith S. D. turner (Edition 1).	1993
15	Analysis of tropical cyclone forecast errors	S. Coulter	1994
16	Monitoring wind observations from the Capel Dewi MST Radar.	A. M. Radford	1994
17	Report on forecasting the probability of NO_2 air quality events using model output statistics.	C. Strudwicke	1994

CENTRAL FORECASTING TECHNICAL NOTE

NUMBER	TITLE	AUTHOR	DATE
18	Examination of bogus and supported observational data in the operational suite.	Mr S. Waters	1994
19	Subjective assessment of the 'Ambiguity Removal Confidence' for scatterometer winds derived from ERS-1	Mr S. Waters	1994
20	Results from a parallel trial to investigate the use of satellite cloud motion winds.	Mr. A. M. Radford	1994
21	Anomaly correlation coefficients for the global model.	Miss C. Dunlop	1994